



# **Commercial Crew Program (CCP) NAC HEOMD Committee Status**

**Steve Stich**  
**Deputy Manager, Commercial Crew Program**

**July 24, 2017**





# Purpose & Agenda



- **Purpose:** To brief the NASA Advisory Council HEOMD Subcommittee on the latest status and technical progress for the CCP CCtCap and CCiCap contracts
- **Agenda:**
  - **CCP Execution Status**
    - Program Progress
    - Milestone Summary
    - Top Risks
  - **CCtCap Status**
    - Boeing Commercial Provider Status
    - SpaceX Commercial Provider Status
  - **CCiCap Status**
    - Blue Origin Status
    - Sierra Nevada Status
  - **Summary**



# Program Progress



**CCP has made significant progress over the last quarter, notably:**

- **Mission planning and preparations for eight CCP missions are in work:**
  - Official Dates For Boeing:
    - June 2018: Orbital Flight Test (uncrewed)
    - August 2018: Crewed Flight Test
    - PCM-1 awarded May 2015; Completed four milestones to date
    - PCM-2 awarded in December 2015; Completed four milestones to date
  - Official Dates For SpaceX:
    - February 2018: Flight to ISS without crew (Demo Mission 1)
    - June 2018: Flight to ISS with crew (Demo Mission 2)
    - PCM-1 awarded November 2015; Completed three milestones to date
    - PCM-2 awarded July 2016; Completed two milestones to date
- **Recovery trainers for both providers have been delivered and rescue training preparations are underway**
- **Continued engagement as the providers perform critical test and verification events**
- **Continue to make progress in the burn down of key certification products with the providers**
  - Progress for each provider is included in provider-specific sections of this briefing



Data Source: Boeing FY17Q2 / SpaceX FY17Q2

- Required Milestone (RM)
- Boeing Milestone 4
- SpaceX Milestone.



# CCP Top Programmatic Risks

## 6/20/2017



LxC	Trend	Risk Title	Risk ID Number	Office
5x4	NC	DOD Search and Rescue Posture	CCP-GMO-2015-3	GMO
3x5	NC	Inability to Meet LOC	CCP-SEI-2015-1	SE&I
4x2	NC	Ammonia Emergency Response	CCP-SC-2016-3	SC
2x4	NC	DoD Search and Rescue Training Schedule	CCP-GMO-2015-4	GMO

Trend Key: New = New Risk, NC = No Change,  
I = Increase in Risk, D = Decrease in Risk, C = Closed, A = Accepted

5				1	
4	1				
3					1
2				1	
1					
	1	2	3	4	5

Consequence

**Programmatic Risk = Likelihood x (Highest of Non Safety Consequences (Cost, Schedule, Performance))**



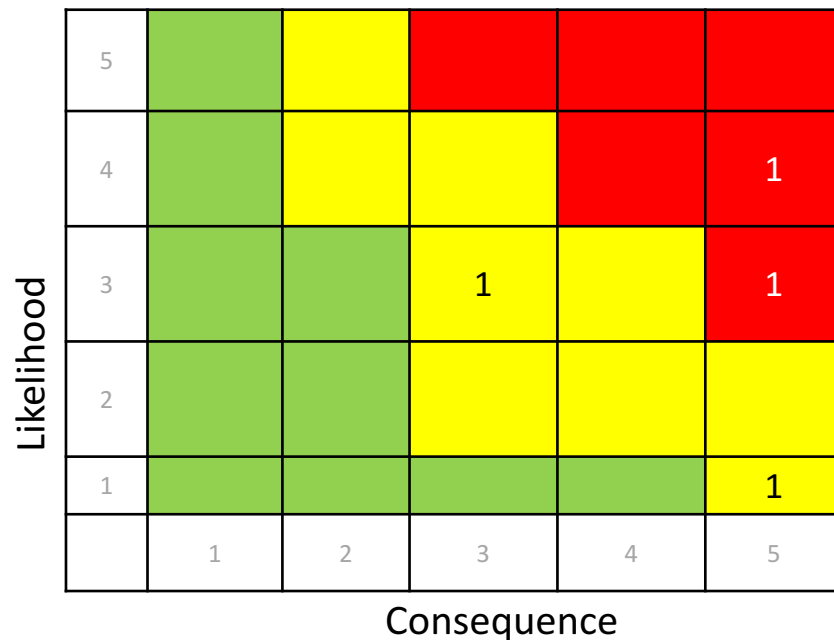
# CCP Top Program Safety Risks

## 6/20/2017



LxC	Trend	Risk Title	Risk ID Number	Office
4x5	NC	Inability to meet LOC	CCP-SEI-2015-1	SE&I
3x5	NC	Aborting into Sea States with Unsafe Rescue	CCP-GMO-2016-3	GMO
3x3	NC	Crew Entry Accelerations and Spaceflight Associated Neuro-ocular Syndrome (SANS) Exacerbations	CCP-IP-2016-3	IP
1x5	NC	Ammonia Emergency Response	CCP-SC-2016-3	SC

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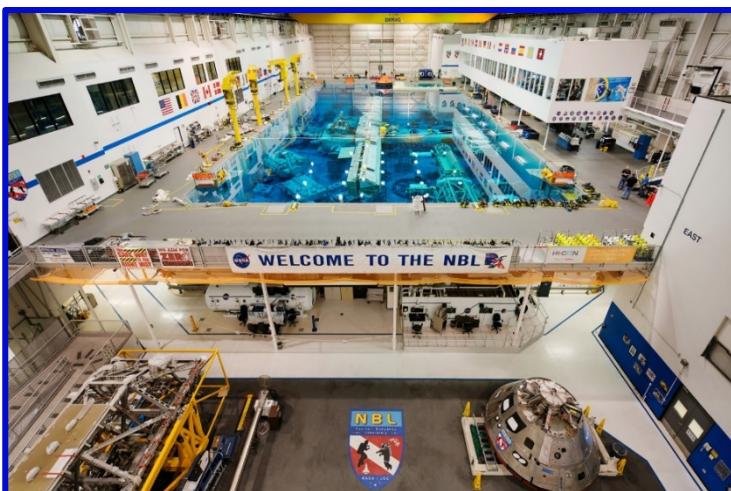
**Safety Risk = Safety Likelihood x (Highest of Safety Consequences (Personnel, Environmental, Facilities))**



# Search and Rescue Status



- **Rescue trainers for both Providers have been delivered and procedure development for search and rescue training exercises will soon be underway**
  - Boeing boilerplate modifications completed in June 2017
    - Boilerplate 3 (BP-3) delivered to NASA on June 30, 2017
    - DoD rescue procedures development is planned for Fall 2017 at Neutral Buoyancy Lab
  - SpaceX “Recovery Trainer” modifications completed
  - Joint modifications between SpaceX and KSC Prototype Lab are in work
    - DoD rescue procedures development initial training took place in June 2017



**Boeing to use NBL for process training**



**SpaceX Recovery Trainer in Banana River**



# Boeing Status





# Boeing Completed Milestone/Event Status



- **Completed:**

- **May 2017:** Boeing delivery of Parachute Compartment Drop Test Vehicle (PCDTV) (lawn dart) for modifications for Parachute Testing
- **May 2017:** Delivery of Boeing Mockup Trainer (BMT)
- **June 2017:** Structural Test Article (STA) Crew Module Forward Heat Shield Shock Test (jettison) complete
- **June 2017:** STA Service Module Fixed Base Structural Tests complete
- **June 2017:** Boiler Plate 3 delivery for Rescue Training
- **June 2017:** Ammonia Response Power Up Procedure and Stowage Development Initiated

- **Upcoming**

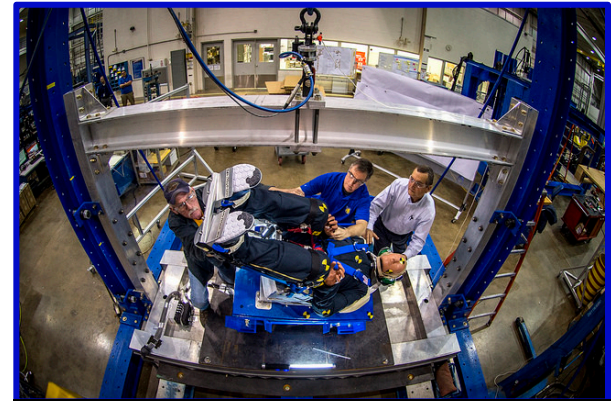
- **Jul 2017:** Spacecraft 1 (SC1) Upper and Lower Dome mating
- **Jul 2017:** Service Module Hot Fire (SMHF) Article first light (power on)
- **Jul 2017:** SMHF Article ship to White Sands Test Facility (WSTF)
- **Jul 2017:** STA Modal Testing
- **Sept 2017:** Parachute Drop Test #2



# Boeing Accomplishments- Hardware/Software Testing



- Parachute System Qualification Test (PSQT) #1 complete
- Spacecraft 1 Lower Dome avionics initial activation complete
  - Data flow to Boeing Mission Control Center at Johnson Space Center (JSC)
- Land Landing Qualification Test (LLQT) 1B2 seat drop tests
- Emergency Detection System (EDS) Integrated Abort Testing at United Launch Alliance (risk reduction)
- ISS Joint Test #2 (JT#2) completed with partial hardware set
- JT#2 will be repeated this summer with full hardware
- Crew Module /Service Module Separation wind tunnel testing
- Starliner avionics / NASA Docking System (NDS) risk reduction test completed
- Boeing and ULA completed successful CDR of aeroskirt design



**1B2 seat drop testing**



**Model for wind tunnel testing**



# Boeing Accomplishments-Launch Pad and Crew Training



- Crew Access Tower outfitting continues
  - Emergency Egress hardware delivered and installed in April 2017
  - Mockup Trainer installed in Building 9 at JSC
  - Mission Simulator installed in Building 5 at JSC



Crew inspect Boeing Mission Simulator



Emergency Egress System testing



# Boeing Accomplishments- Production and Qualification



- **Production & Qualification**

- Spacecraft #1 pre-mate interface tests complete and backshell closeouts in work
- Service Module Hot Fire doghouse and pressurant system installation and initial leak checks complete
- Launch Vehicle assignment made: AV-080



Spacecraft 1 powered up inside Boeing's 3CPF



Spacecraft 2



# Boeing Accomplishments- Structural Test Article



- **Demonstration & Test**

- Continued progress with Structural Test Article campaign
  - Proof Pressure Test complete
  - Influence Coefficient Test complete
  - Service Module Fixed Base Structural Test complete
  - Ascent Cover and Landing/Recovery Systems Shock Tests in progress
  - Commercial Crew Transportation Services Modal testing

- **Facility Preparation**

- C3PF Hazardous Processing Area Utilized for Service Module Hotfire Test Article Prep
- If an RF comm test using fiber connection between labs is successful, an option to use fiber connection will be considered for final verification of Starliner-to-ISS RF and hardline communications and data interface testing



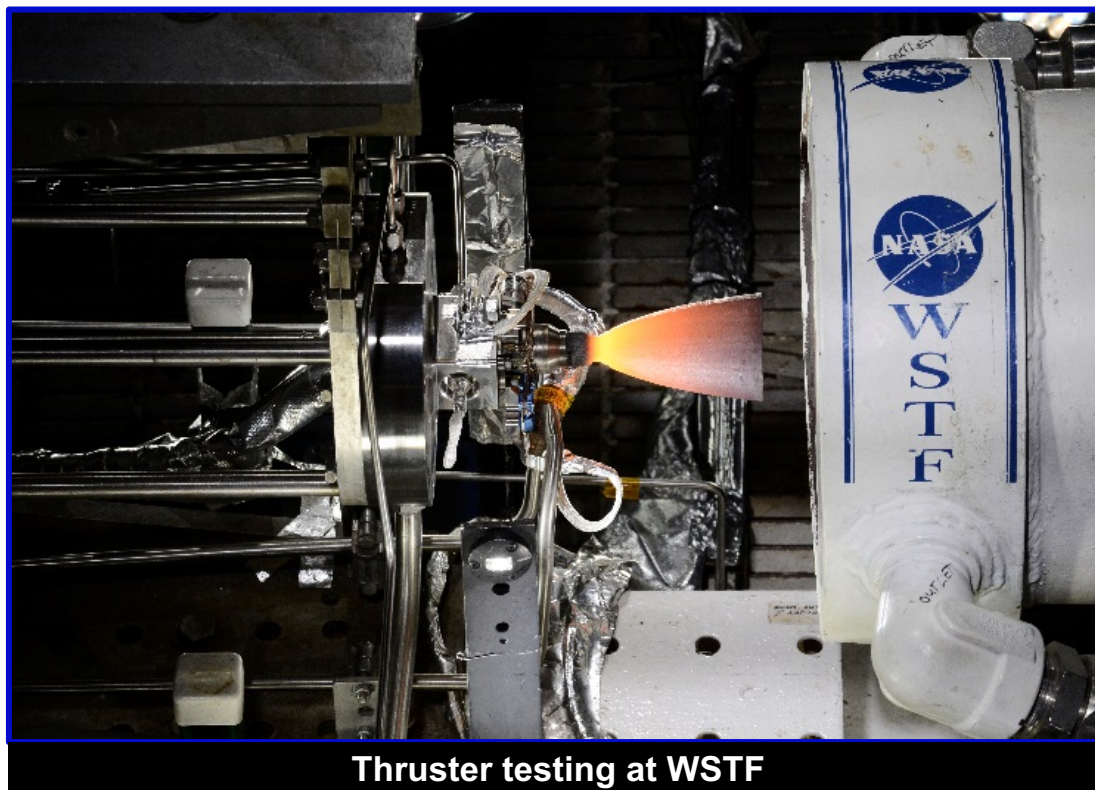
**Structural Test Article**



# Boeing CFT Thruster Testing Underway



- White Sands Test Facility performing Acceptance Test Procedure (ATP) testing of all Service Module (SM) engines for the CST-100 for CFT
- Hotfire testing to date:
  - 7 OMAC thrusters
  - 3 RCS thrusters
- TS301A development underway, with facility ready for testing in late July 2017
- Launch Abort Engine (LAE) testing at WSTF in August 2017



Thruster testing at WSTF



# SpaceX Status





# SpaceX Completed Milestone / Event Status



- **Completed:**

- **June 2017:** Vehicle Baseline Review Crew 2 (Funded)
- **July 2017:** Flight Test Certification Review (FTCR) Part 1 (Funded) Closed

- **Upcoming:**

- **Aug. 2017:** Crew 1 Mission Integration Review(MIR) Part 2 (Funded)
- **Nov. 2017:** Crew 2 MIR (Funded)
- **Dec 2017:** FTCR Part 2 (Funded)
- **Feb. 2018:** Demo 1 Flight to ISS Without Crew (Funded)
- **Mar 2018:** Validation Prop Mod Testing Complete (Funded)
- **Mar 2018:** Parachute Qual complete
- **Mar 2018:** Design Certification Review (DCR)
- **Apr. 2018:** In-Flight Abort (IFA) Test
- **Apr 2018:** Flight Test Readiness review
- **June 2018:** Demo 2 Crewed Flight to ISS
- **Aug. 2018:** Operations Readiness Review (ORR)
- **Sept. 2018:** Certification Review (Funded)



# SpaceX Accomplishments- Hardware and Software Testing



- **Hardware and Software Testing**
  - Buck returned from vendor after interior panel installation in July, same panels being built for Demo-1
  - 2 Hardware-in-the-Loop (HITL) tables assembled in support of software testing with flight computers and vehicle Remote Input Output units
  - Performed acceptance testing of Demo-1 components including heatshield
  - Continued Validation Propulsion Module Build up for McGregor test



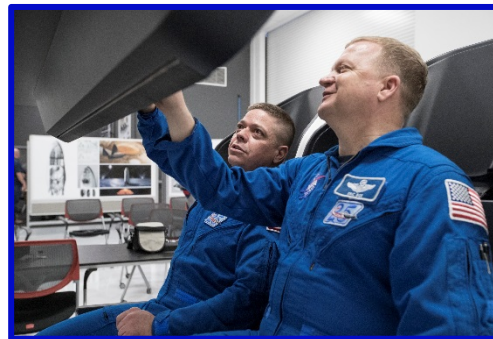
**Dragon 2 Weldment and Heatshield**



# SpaceX Accomplishments- Launch Pad and Crew Training



- **Completed inaugural flight, CRS-10, out of LC-39A in Feb 2017**
  - Completed 8 launches in the last 6 months, 2 additional flights planned for Aug 2017
- **Completed upgrades to lightning mast and lightning protection system**
  - Extending height of lightning mast
  - Installed additional down conductors on launch site
- **Crew Training**
  - Completing multiple Human in the Loop (HITL) and software simulations including launch-to-dock



Touring the Crew Dragon simulator

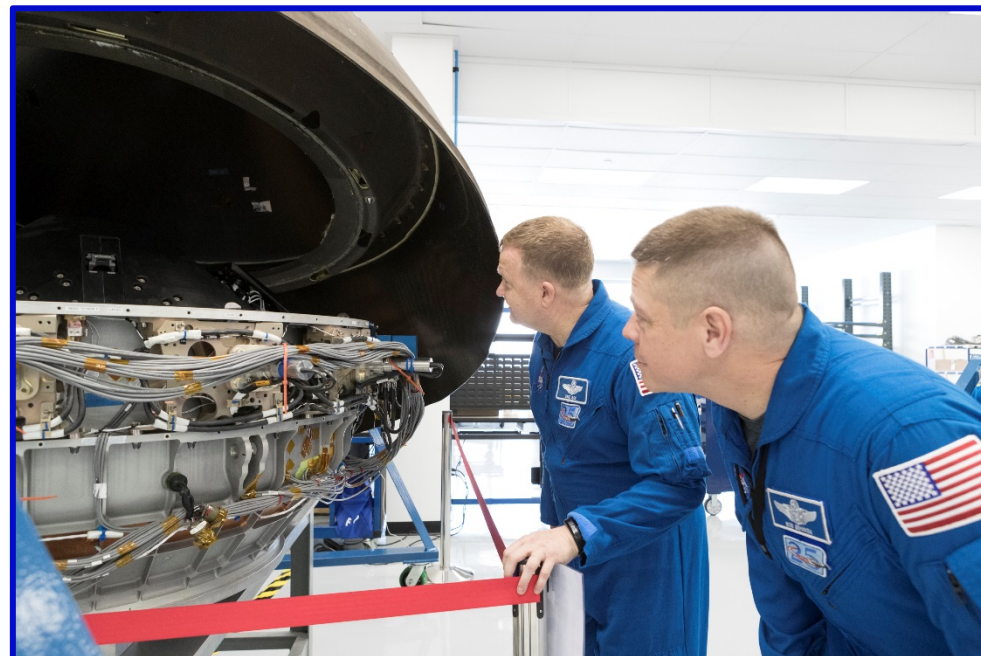


# SpaceX Accomplishments-Hardware Production and Qualification



- **Production and Qualification**

- 4 Dragon Modules in are production: Qual Module, Demo Mission-1, Demo Mission-2, and Crew 1
- Qual module structural testing complete
- Demo-1 service section integration with pressure vessel in work
- Demo-1 leak test complete on individual pressure vessel penetrations
- Demo-2 module repainted
- Performed qualification testing of Dragon claw, engines and other components
- Crew 1 aft and forward bulkheads manufactured and ready to weld on lower cylinder
- Completed Joint Test 7, ISS Power Interface Test
- Parachute drop test campaign is ongoing; 6 successful drops to date



**Examining the spacecraft during production**



# SpaceX Accomplishments-Space Suits and Water Egress Development



- **Performed first pressurized test with crew wearing space suits**
  - Successful test and results gathers will inform updates to patterns and incorporate simple fixes
- **Completed Recovery Trainer "First Look"**
  - Activities focused on using the Recovery Trainer for various DoD rescue focus areas, including GSE installation, safety checks of capsule systems, and hatch operations



Recovery Trainer test in Banana River



# SpaceX Accomplishments



- **Design**

- Dragon
  - Completed the first pressurized space suit test utilizing NASA crew
  - Majority of fluid system assembly releases completed for prop module
  - Open work items include:
    - Final maturation of displays and seat mechanisms
- LC-39A
  - Launching from LC-39A
    - Water Deluge Sound Suppression Test
    - Crew access arm and white room installation planned later this year
- F9
  - Merlin 1D and Merlin Vacuum Engine (MVAC) in development testing
  - Continuing to partner Falcon 9 block upgrades in support of design implementation closure



Checking out the access arm



# Blue Origin Accomplishments



## Blue Origin

### Commercial Space Capabilities Collaboration (CSCC) Space Act Agreement (SAA)

- **Technical Exchanges**

- Radiation Tolerance and Avionics Design
- SLS Structures: Design, Materials, and Analytical Techniques
- Fire Safety (SAFFIRE outbrief)
- Environmental Corrosion Test Site Capabilities (KSC)
- Hot Gas Facility Capabilities (MSFC)
- Navigation Development (GSFC)
- Milestone #3: May 2017
  - Progress Review of New Shepard Subscale Crew Transportation System (Blue Origin Facility)

- **Data Exchange**

- Various software requests and technical documentation exchanges in work

- **Look Ahead**

- Milestone #4, Nov 2017
  - Progress Review of Rocket Propulsion Systems
- Continued Technical and Data Exchange





# Sierra Nevada Corp. Accomplishments



- **Extended CCIcap Space Act Agreement to Aug 2022 and add 8 new unfunded milestones in support of continued crewed capability development**
- **Approach & Landing Test 2 (ALT-2) is CCIcap Milestone 4B**
  - Full scale Dream Chaser engineering test article (ETA) unpowered approach & landing test (ALT-2) at Armstrong Flight Research Center/Edwards Air Force Base, Fall 2017
- **Successfully executed a large number of integrated tests to verify system design requirements and validate system function in preparation for ALT-2 test**
  - Flight software regression
  - Airborne Ground Resonance
  - Inertial Navigation System Boresight & Laser Scan
  - Vehicle Moments Of Inertia
  - Tow and Brake Testing
  - Airborne Gain Margin Test
  - Flush Air Data System
  - Remaining significant Integrated Test activities
    - Day In The Life Test (final)
    - Combined Systems Test (final)
    - ETA Captive Carry Test #1, & #2 –Fall 2017
    - ETA Approach and Landing Test #2 (ALT2) – Fall-2017





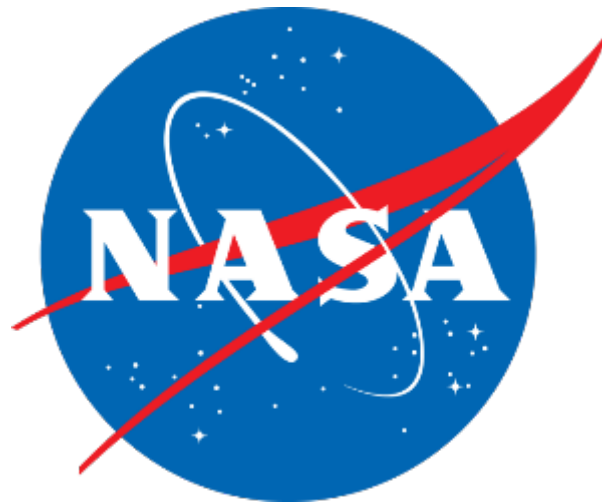
# CCP Summary



- **CCP continues to facilitate the development and certification of U.S. industry-based crew transportation systems**
- **Boeing and SpaceX are meeting contractual milestones and maturing their designs**
  - A significant amount of hardware is in development and test in preparation for upcoming missions
  - Risks are being identified and important design challenges are being addressed
  - NASA is engaged in meaningful insight
- **Recovery trainers for both Providers have been delivered and rescue training preparations are underway**
- **Spacesuits have been developed by both Providers**
- **CCP has robust and efficient processes for certification including addressing waivers and deviations**
  - Progress is being made in the burn down of key certification products with the providers
- **In preparation for flight, there is significant work ahead**



**COMMERCIAL CREW PROGRAM: THE MISSION IS IN SIGHT**





# Acronyms & Abbreviations



- **ALT:** Approach & Landing Test
- **AoA:** Angle of Attack
- **ATCS:** Active Thermal Control Subsystem
- **BP:** Boilerplate
- **Calysto:** Risk Management tool
- **C3PF:** Commercial Crew and Cargo Processing Facility
- **CCiCap:** Commercial Crew integrated Capability
- **CCtCap:** Commercial Crew transportation Capability
- **CDR:** Critical Design Review
- **CFA:** Computational Fluid Analysis
- **CFT:** Crewed Flight Test
- **CM:** Crew Module
- **COPV:** Composite Overwrap Pressure Vessel
- **CPWSR:** Configuration Performance & Weight Status Report
- **CSCS:** Contingency Spacecraft Crew Support?
- **CTS:** Crew Transportation System
- **DCR:** Design Certification Review
- **DDT&E:** Design, Development, Test & Evaluation
- **Det3:** (USAF) Detachment 3
- **DM:** Demonstration Mission
- **ECLSS:** Environmental Control and Life Support System
- **ECM:** Electro-Chemical Machining
- **EDM:** Electron Discharge Machining
- **EDS:** Emergency Detection System
- **ETA:** Engineering Test Article
- **FHS:** Forward Heat Shield
- **FLT:** Flight
- **FOD:** Flight Operations Directorate
- **FTCR:** Flight Test Certification Review
- **GMO:** Ground & Mission Operations
- **HAR:** Hazard Analysis Report
- **HITL:** Human in the Loop
- **HR:** Hazard Report
- **HRCP:** Human Rating Certification Package
- **IDA:** International Docking Adapter
- **IFA:** In-Flight Abort
- **IV&V:** Independent Verification & Validation
- **JIRA:** Project management software tool
- **JPRCB:** Joint Program Requirements Control Board
- **JT:** Joint Test
- **LAE:** Launch Abort Engine
- **LLQTL:** Land Landing Qualification Test
- **LOC:** Loss of Crew
- **LOM:** Loss of Mission
- **LSC:** Linear Shaped Charge
- **LSORR:** Launch Site Operational Readiness Review
- **LV:** Launch Vehicle
- **LVA:** Launch Vehicle Adapter
- **MIR:** Mission Integration Review
- **MMOD:** Micrometeoroid and Orbital Debris
- **MVac:** Merlin Vacuum Engine
- **NDS:** NASA Docking System
- **NBL:** Neutral Buoyancy Lab
- **NESC:** NASA Engineering & Safety Center
- **NLA:** Non-Linear Aero
- **OFT:** Orbital Flight Test
- **OMAC:** Orbital Maneuvering and Attitude Control
- **OML:** Outer Mold Line
- **ORDEM:** Orbital Debris Engineering Model
- **ORR:** Operational Readiness Review
- **PAA:** Product Assurance Analysis
- **PAFB:** Patrick Air Force Base
- **PAT:** Pad Abort Test
- **PC&I:** Program Control & Integration
- **PCB:** Program Control Board
- **PCDTV:** Parachute Compartment Drop Test Vehicle
- **PCM:** Post Certification Mission
- **PDR:** Preliminary Design Review
- **PnP:** Probability of No Penetration
- **PSA:** Probabilistic Safety Analysis
- **PJ:** Para Jumpers
- **RCS:** Reaction Control System
- **RT:** Rescue Trainer
- **SC:** Spacecraft
- **SE&I:** Systems Engineering & Integration
- **SM:** Service Module
- **SOW:** Statement of Work
- **STA:** Structural Test Article
- **STRB:** Safety Technical Review Board
- **SureSep:** LVA Jettison System
- **TIM:** Technical Interchange Meeting
- **TM3:** Targeted Mass 3
- **TPS:** Thermal Protection System
- **TTP:** Tactics, Techniques, & Procedures
- **TRR:** Test Readiness Review
- **UDA:** Universal Docking Adapter
- **ULA:** United Launch Alliance
- **USAF:** US Air Force
- **VBR:** Vehicle Baseline Review
- **VCN:** Verification Closure Notice
- **VE:** Verification Event
- **VIIP:** Vision Impairment/Intracranial Pressure
- **WSTF:** White Sands Test Facility
- **WTT:** Wind Tunnel Testing